CHAPTER 5

LINK-11 FAULT ISOLATION

INTRODUCTION

A communications network, such as the Link-11 system, can be very complex when the goal is to maintain high-quality communications with all units in the net. Distance, atmospheric anomalies, corrosion, and even the time of day can affect the quality of Link-11 communications. The Link-11 technician has many tools to enable him to pinpoint problems. However, oftentimes the technician may misunderstand such tools, forget them, or not have the knowledge to use them effectively.

Problems occurring with Link-11 communications are best approached by means of the team concept. A typical link team is usually composed of a team leader, an ET, a FC, an OS, and an RM. The team leader is usually a senior ET and could be the electronics material officer (EMO) or combat systems maintenance officer.

After completing this chapter, you should be able to:

- **Describe the procedures required for running single station Programmed Operational and Functional Appraisal (POFA) on the DTS.**
- **State the circuits verified by the successful completion of single station POFA.**
- **Describe the procedures for running multi-station Link-n POFA.**
- **Describe the components of the LMS-11.**
- **Describe the information presented in each of the LMS-11 display modes.**
- **Recognize common Link-n problems as displayed on the LMS-11.**

LINK-11 MYTHS AND FACTS

When a Link-11 problem occurs, usually the link troubleshooting team is called to the combat direction center. Here they can meet with the operator, talk to other ships in the link, and analyze the displays on the LMS-11. Through these initial steps, the team can determine several things, such as whether the problem is local or if the entire net is experiencing problems. Because of the complexity of link equipment, a variety of methods were used over the years to solve link problems. If a particular action worked once, it was often assumed that it would work in all instances. Over the years, this led to a type of folklore or mythology on how technicians were to troubleshoot the link. Senior link techs would pass these myths on to junior link techs and the mythology developed a life of its own. In the following paragraphs, we examine some of these myths and seek to clarify the real problems that led to the evolution of them.

Myth: Changing the NCS Will Always Solve Net Problems!

Changing the NCS may solve net problems, but only if the current NCS is causing the problem. What is the problem? If data is not being received from a unit because the current NCS has entered the PU number incorrectly, shifting NCS functions to a station with the PU data entered correctly will solve the problem. However, it would be easier if the current NCS were simply to enter the correct PU numbers.

When the current NCS is using a radio set with poor receiver sensitivity and is polling on top of picket responses effectively jamming the entire net, changing the NCS is imperative. Also, if several units are not recognizing their interrogations because NCS is out of range or in an RF propagation shadow, changing to a unit in a better location should improve net communications.

Myth: Changing Frequency Always Solves Net Problems!

Here again is a myth that has some basis of fact. Changing frequency is a time-consuming process. When all the procedures are not carefully followed, then changing the frequency induces additional problems into the net. This myth developed because improperly set switch positions and patch panel configurations were often set to the proper position during the frequency changing process. When the problem is connectivity on the current frequency, the proper action is to find a better frequency.

Myth: More Power Improves Link Performance!

This is a myth. On the transmit side, the idea behind the myth is that keeping the link HF transmitter tuned to maximum output power will result in maximum area coverage. In fact, constantly outputting maximum power can lead to serious RFI/EMI problems (on the ship doing so) and will not significantly increase the signal propagation range.

The idea behind the myth on the receive side is that by keeping the HF receiver audio output control maximized, receive quality improves. In fact, maximizing the audio output saturates most data terminal sets. Saturation generally occurs in the DTS at around 3 dBm. Signal inputs above this level actually increase receive data errors.

Myth: Dummy PUs Improve Link Quality!

A dummy PU is an address insert into the polling sequence by the NCS for which there is no live unit. Dummy PUs cause the net cycle time to increase and net efficiency to decrease. The idea that the NCS must use dummy PUs for the link to operate properly is not generally true. It may be true only in infrequent, isolated cases. Studies have shown that in the old NTDS system (CP-642 computer and the AN/USQ-36 DTS), a dummy PU entered between a live PU and own address was required for NCS data to be output at each NCS report opportunity. Since the CP-642 computer and the AN/USQ-36 DTS have virtually disappeared, dummy PUs should not be used.

Myth: Radio Silence Reduces Net Cycle Time!

The effect Radio Silence has on net cycle time depends on a number of factors. As you saw in the last chapter, if a PU does not respond to a call up in 15 frames, the PU is interrogated again. After another 15 frames, if the PU still does not respond, then NCS polls the next PU. If the PU that goes to Radio Silence was sending reports that exceeded 38 frames, then net cycle time would be reduced by the PU going to Radio Silence. Effective net management would be to eliminate the PU number of the unit that has to go into Radio Silence until that unit is able to reenter the net.

As you can see, there are several misconceptions on the proper way to manage and troubleshoot the Link-11 system. In this chapter, we concentrate on the tools available to the technician to aid in the isolation of link problems.

LINK-11 PROGRAMMED OPERATIONAL AND FUNCTIONAL APPRAISAL (POFA)

Two types of POFAs are used in the Link-11 system. These are the single station POFA, used to check components of the Link-11 on board a single station, and the multi-station POFA, used to check the connectivity of several units.

SINGLE STATION POFA

The single station POFA is an end-around test that transfers canned data from the computer through the crypto device and the data terminal. The single station POFA can also be run through the radio set to check out part of the audio communications path further.

POFA Setup

The POFA is a special program that is loaded into the computer. It is very important that you follow the instruction manual when attempting to run the POFA. The POFA is designed to run in full-duplex mode. Normal link operations use the half-duplex mode. “Full duplex” means the system is configured to transmit and receive data at the same time. In the DTS, this is accomplished by the transmit audio being fed directly into the receive input. Also, if the DTS is operating in full-duplex mode, the rest of the system, especially the crypto device, must be in full duplex. On the KG-40, full duplex is accomplished when the front panel switch is turned to the POFA TEST position.

Analyzing Single Station POFA

When a single station POFA is completed, a printout of the results is produced. To analyze this printout properly, the technician must understand

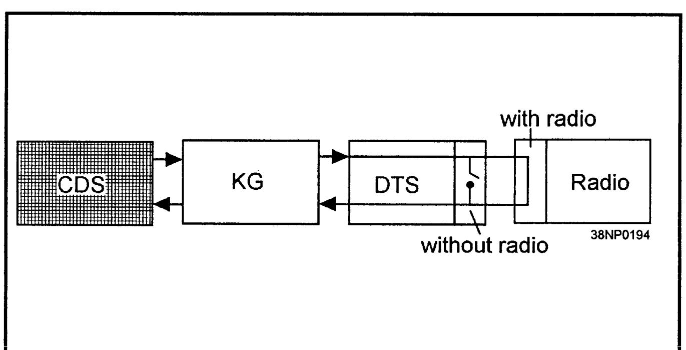

Figure 5-1.—Single station POFA configurations.

what equipment is being tested. The configuration in which the POFA was run determines some of the equipment being tested. The POFA can be run in two configurations, as shown in figure 5-1.

In the full configuration, the single station POFA will test the following areas:

- CDS computer I/O channel interrupt recognition and acceptance
- Security device I/O path
- Data terminal transmit and receive registers, multiplex and demultiplex, and transmit and receive sequence operations
- Switchboard integrity
- DTS-to-radio and radio-to-DTS audio path
- Capability of the HF radio set to develop and accept sidebands (both transmit and receive).

By studying the above list, you can see that most normal link operations are tested during a single station POFA. Certain functions, however, are not checked by running a single station POFA. The DTS uses the transmit timing as the reference for the entire test; therefore, the receive timing circuitry is not checked. Also, certain other functions, such as Doppler correction, are not checked.

The printout generated at the end of a single station POFA lists interrupt status, illegal interrupts, parity, and bit-by-bit word errors. A single station POFA should always produce a totally error-free printout. However, when a printout with errors is received, the technician needs to be able to analyze the error package effectively.

The interrupts, for example, must occur in the following sequence:

- Prepare to transmit
- Prepare to receive
- End of receive

If you receive interrupts in any other order, such as two consecutive prepare to transmit interrupts or an end of receive before the prepare to receive, an error condition exists.

The parity should always equal zero. As you learned in the previous chapter, the parity, or error detection status bits, indicates an error has been detected in the received data. When errors are detected, they are listed in the bit-by-bit section of the printout.

Even if the printout indicates a few random bit errors, this condition should not be ignored. Random bit errors can be caused by several areas in the system, including the CDS computer, the data switchboard, or the DTS. You can narrow down to the exact area causing the problem by running the POFA in several configurations. Changing computers and crypto devices can aid you in determining the malfunction.

Because of the unique function of the crypto device, a single broken line in the switchboard could cause all the bits to be randomly picked up or randomly dropped. When the broken wire is on the encrypted side of the switchboard, the crypto device reads the state of that line during the decryption cycle and the entire decryption cycle is changed.

MULTI-STATION POFA

The multi-station POFA is a test of the Link-11 system that involves more than one platform. Because this POFA most closely represents normal link operations, more equipment is tested. The multi-station POFA is run in the Roll Call mode using a set of known data words. Figure 5-2 shows the data flow for a multi-station POFA. A designated unit transmits a block of 230 data words that are received by the other platforms involved in the multi-station POFA. The receiving computer(s) compare(s) the data against the known pattern, count(s) the words in error, and send(s) this count back to the original ship. This transmission is known as the error status report. Ideally, the multi-station POFA should run error-free.

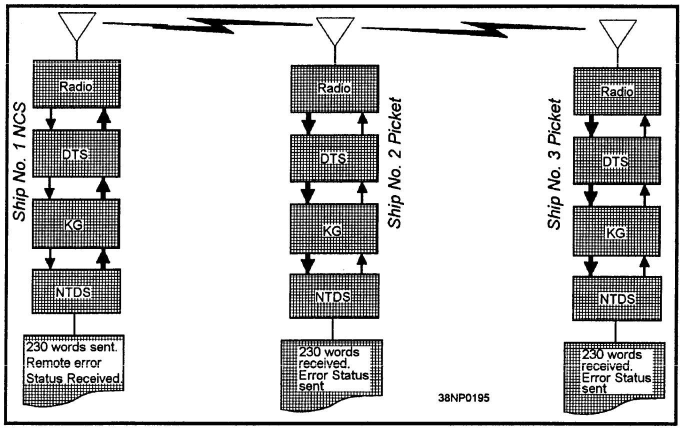

Figure 5-2.—Link-11 multi-station POFA data flow.

Multi-Station POFA Procedures

The procedures for running a multi-station POFA require coordination of all participating units. For this to be a good test, all units must be positioned within 25 miles of each other. This is usually coordinated by the Link-11 manager in conjunction with the battle group commander.

Just before the time the multi-station POFA is to be conducted, NCS should end the operational link and direct all stations to run a single station POFA. The picket station reports back to NCS when the single station POFA has been completed. The picket station will also report the status of the single station error printout. Any errors noted during single station POFA should be corrected before the multi-station POFA, or the station experiencing errors should not be included in the multi-station POFA.

The multi-station POFA should be run using the same frequency as the current operational frequency. After running the single station POFA, NCS should direct all participants to go to Radio Silence. During this time, all stations should monitor the assigned frequency for noise. The frequency can be monitored through the headphones or by using a frequency analyzer. A noisy frequency can cause errors in the multi-station POFA. If the frequency is too noisy, consider using an alternate frequency.

Once the frequency has been checked, NCS will tell all participants to prepare to receive POFA. After all stations report that they are ready, NCS initiates the POFA. All stations monitor the POFA, and check the control panel of the DTS for errors. After a minimum of 5 minutes, NCS terminates the POFA.

When the POFA is terminated, a printout is generated. The final step in running a multi-station POFA is the analysis of the printout.

Analyzing Multi-Station POFA Results

Running a multi-station POFA closely approximates actual link operating conditions. To analyze the printout fully, the technician needs to be aware of some of the factors that can affect link operations.

When the printout is completed, the analysis is easier to complete if the technician records the following information on the printout:

- Which station is NCS
- Distance and relative bearing of all participating units
- Frequency used
- Frequency quality
- Equipment used (radio, trunk line, computer, crypto, etc.)
- Start and stop time of the POFA

The printout will contain a summary of the activity that includes the time, in minutes and seconds, that the station was on the air, the total number of words transmitted, the total number of words received, and the total number of words with errors. This information can be used to calculate the **link quality factor.** To calculate the link quality factor, divide the number of words received by the number of words transmitted. When the quotient is greater than 95 percent but less than 100 percent, consider the POFA successful.

Next, compute the receive error factor. Ideally, the POFA should run with zero errors. Since the multi-station POFA is transmitted, atmospheric interference, ship's position, antenna location, and EMI are just a few of the things that can induce errors in a radio signal. Determine the receive error factor by dividing the number of words with errors by the number of words received. When the receive error factor is less than 1 percent, consider the POFA successful.

When the printout indicates that data was received from an unrecognized station (UNREC STA), the technician should check the number of words received. The multi-station POFA transmit buffer consists of 230 words. One buffer of 230 words from an unrecognized station is acceptable and generally does not indicate a problem. More than one buffer may indicate a problem, but multiple buffers from an UNREC STA can also be caused by interference on the frequency.

The printout will also indicate the parity status of the words received in error. During the POFA, since the computer knows the contents of the received data block, it performs a parity check on all received words. These parity checks are compared with the parity status received from the DTS. The printout indicates these parity checks. The heading PARITY STATUS OF ERROR WORDS lists the number of error words detected by the DTS and the parity (1, 2, or 3). The heading PARITY STATUS OF CORRECT WORDS indicates the computer parity check of words received as correct from the DTS. When an error is detected, the number of words in error for each of the three parity status conditions are listed here. The final part of the printout indicates the remote station reports. These reports are sent by other stations as part of the data transferred during the POFA.

Since a multi-station POFA is subject to various types of interference, both natural and man-made, several attempts may be required for you to achieve acceptable results. Shifting NCS and repositioning the ships are just two of the actions that could contribute to achieving a successful multi-station POFA.

THE LINK-11 MONITORING SYSTEM (LMS-11)

"The link is down" is a statement that can strike fear into even the most seasoned technician. As we have seen, the operation and maintenance of a high-quality link can be affected by many factors. For years, operators and technicians commonly blamed each other for poor link operations. Some typical Link-11 problems are as follows:

- Participating units (PUs) not responding to call-ups
- Garbled data
- The link goes completely dead, normal operation ceases
- Inability to establish a net
- Excessive net cycle time

When such a problem occurred, the Link-11 technician would run a single station POFA and declare that the DTS was sound and it must be the other ship, a poor frequency, or an operator error. The operator would blame the frequency or NCS. Other units would say the problem was another platform jamming the entire net. Typical strategies used to solve link problems usually began with a recommendation to change frequency. When this strategy failed to solve the problem, the next step was to change NCS. If the problem still existed, then NCS would eliminate PUs from the net, one at a time until the problem unit was identified. All of these actions took time and were hit-and-miss techniques. This tendency of trial-and-error troubleshooting and pointing fingers defined the need for a reliable visual system of monitoring the Link-11 network.

This need was filled with the development of the Link Monitoring System, AN/TSQ-162(V)1, commonly called the LMS-11. The LMS-11 provides an operator or a technician with a real-time visual display of the Link-11 network while it is operating.

The LMS-11 is capable of measuring and displaying link signal data for the network as a whole, as well as for individual units. It can be used for periodic equipment checks or for continuous monitoring to determine the condition of all members of the net.

LMS-11 SYSTEM CONFIGURATION

The LMS-11 consists of three groups equipment: a data processing group (DPG), a control/display group (CDG), and an accessory group (AG). The LMS-11 is shown in figure 5-3.

The LMS-11 is designed to be portable, and the equipment is installed in three carrying cases. The equipment cases that house the electronic units of the DPG and CDG provide isolation from shock and vibration. The CDG is designed to be mounted on the DPG cases. Four latches fasten the two units together and provide a desk height, self-contained workstation. The system printer, which is part of the accessory group, is mounted on the top of the CDG equipment case. When the LMS-11 is installed, the accessory group case provides storage for the DPG and CDG equipment case covers. The LMS-11 is normally located near the data terminal set, but it may be installed anywhere near a 600-ohm Link-11 audio signal.

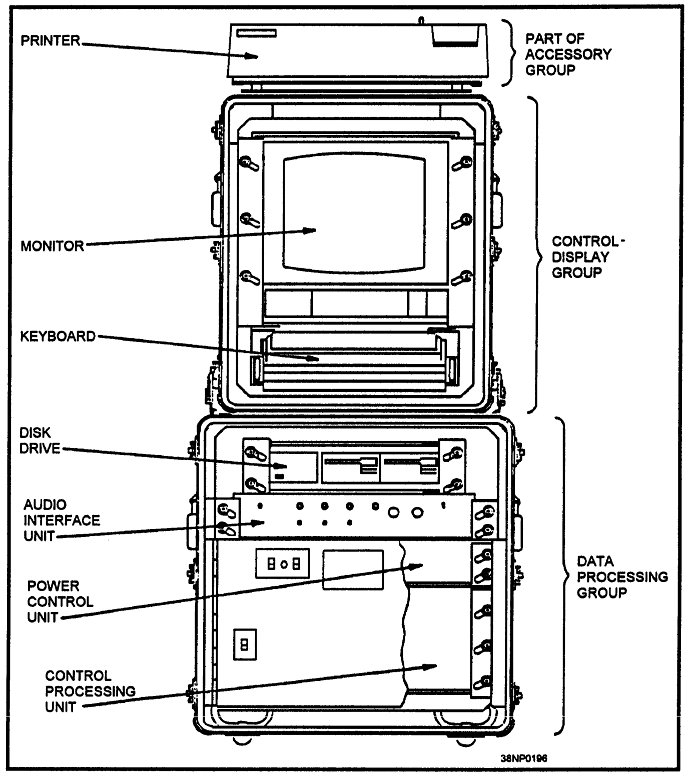

Figure 5-3.—The LMS-11.

Data Processing Group

The equipment required for the LMS-11 to receive, sample, and process Link-11 audio signals is contained in the data processing group. The DPG also provides power control and distribution to the CDG and accessories. The DPG consists of the following equipment:

- The control processing unit
- The audio interface unit
- The dual 3.5-inch floppy disk drive unit
- The power control unit

CONTROL PROCESSING UNIT. —The control processing unit consists of the HP9920U computer with an additional 2 MB of ram and associated circuit card assemblies (CCA). These circuit cards include the following:

- Color output CCA
- Composite Video CCA
- Data communications interface
- HP interface bus (HP-IB)
- Analog-to-digital converter assembly
- Fast Fourier Transform (FFT) processor

The color output CCA and the composite video CCA provide the necessary signals to drive the color monitor. The data communications interface provides an RS-232C asynchronous serial interface for the color printer. The HPIB is used to interface the system keyboard and the dual disk drives to the computer.

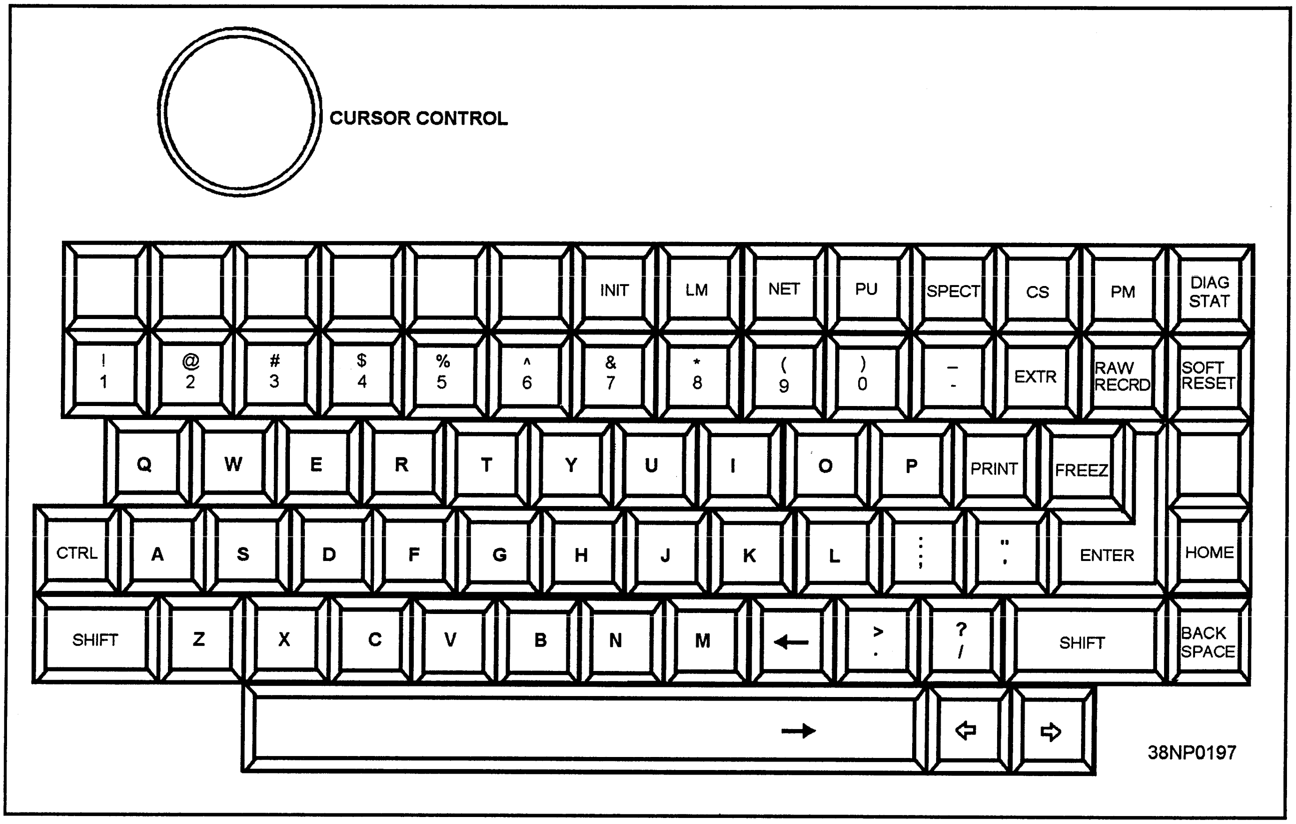

Figure 5-4.—The LMS-11 keyboard.

The analog-to-digital converter converts the Link-11 audio signal into a digital signal for use by the LMS-11. This digital signal is then transferred to the computer where the FFT converts it to a frequency domain. The Fast Fourier Transform consists of a complex mathematical formula used to determine the phase shift of a signal.

AUDIO INTERFACE UNIT. —The audio interface unit connects the upper sideband (USB) and lower sideband (LSB) audio signals from an HF radio or the USB from a UHF radio to the LMS-11. The audio signals are input to the analog-to-digital converter of the control processing unit. The audio interface unit does not add a load to the audio signal.

DUAL 3.5-INCH FLOPPY DISK DRIVE UNIT. —The dual 3.5-inch floppy drive unit is used to load the LMS-11 programs and to record Link-11 data. The disk drives use 788 Kbyte, double-sided, double-density disks.

POWER CONTROL UNIT. —The power control unit provides the control, distribution, and conditioning of the 115 VAC input power.

Control/Display Group (CDG)

The CDG consists of a color graphics monitor and a keyboard. The monitor displays operator-entered data and system operation. The keyboard provides the operator interface with the LMS-11.

COLOR DISPLAY MONITOR. —The color display monitor is capable of displaying both composite and RGB video. The computer generates composite video during the start-up and testing of the LMS-11. The RGB input with an external sync is used for displaying graphics during normal LMS-11 operations. The monitor is also equipped with a speaker and audio input to provide the operator with the capability of monitoring the Link-11 audio signal.

KEYBOARD. —The keyboard is mounted on a tray under the monitor. Under the tray, there is a storage slot for the LMS-11 technical manual. The functional keys on the keyboard are color-coded to facilitate operator selections and entries. The LMS-11 keyboard is shown in figure 5-4.

Many of the keys on the LMS-11 keyboard are not used and the software does not recognize these keys. The actual functions of the keys are covered later in this chapter.

Accessory Group (AG)

The accessory group contains a color graphics printer and spare parts and supplies for the LMS-11. The shipping container is also used to store the DPG and CDG container covers when the printer is removed and mounted on the LMS-11. The color graphics printer is used to provide hard-copy printouts of the display screen on plain paper or clear transparency material.

LMS-11 OPERATION AND DISPLAYS

The LMS-11 provides real-time monitoring of Link-11 operations. Problems with the net can be easily detected in real time and you can determine the cause of the problems by evaluating the different displays. When the cause is determined, the operator or technician can take corrective action.

System Initialization

When the LMS-11 is turned on following the correct power-up sequence, the computer runs a group of self-tests and it then boots the disk in drive 0. When the booting is complete, the LMS-11 monitor displays the following message: **"BOOTING COMPLETE, SWITCH TO RGB."** At this time, the operator should depress the **RGB** button on the monitor. The Initialization display is the first screen displayed after the software is loaded. The operator can also recall the Initialization display by pressing the INIT button of the keyboard. The Initialization display screen is shown in figure 5-5.

During the initialization process, the operator is required to enter the following Link-11 operating parameters:

- DATE and TIME.
- PRINTER. Selects which printer, if any, is being used with the LMS-11.
- NET-MODE. Selects the Link-11 mode: Net Sync, Net Test, Roll Call, Broadcast, or Short Broadcast. The default is Roll Call.
- DATA RATE. Selects whether the link is operating in the fast or slow data rate.
- FREQ-CORR. Enables or disables Doppler correction.
- CALL-TIMEOUT. Allows the operator to specify the number of frames for the missed call timeout. Normal link operations is 15 frames but is increased to 127 frames for satellite link operations.

When all the required data is entered, the operator should select the desired mode of operation for the LMS-11. The five on-line modes are as follows: LINK MONITOR, NET, PU, SPECTRUM, and CARRIER SUPPRESSION.

Each mode has a unique display screen. All display screens consist of the following three parts: the header, the link signal or information area, and the status display. The header is at the top of the screen and indicates the mode being displayed. information area is the middle section of the display, and the status display is at the bottom of the screen. The status display is the same for all on-line modes.

Link Monitor Mode

The link monitor mode display reflects link activity in real time. This display allows the operator or technician to monitor link operations and detect problems as they occur. To select the link monitor mode, the operator presses the function key labeled LM. The link monitor mode display is shown in figure 5-6.

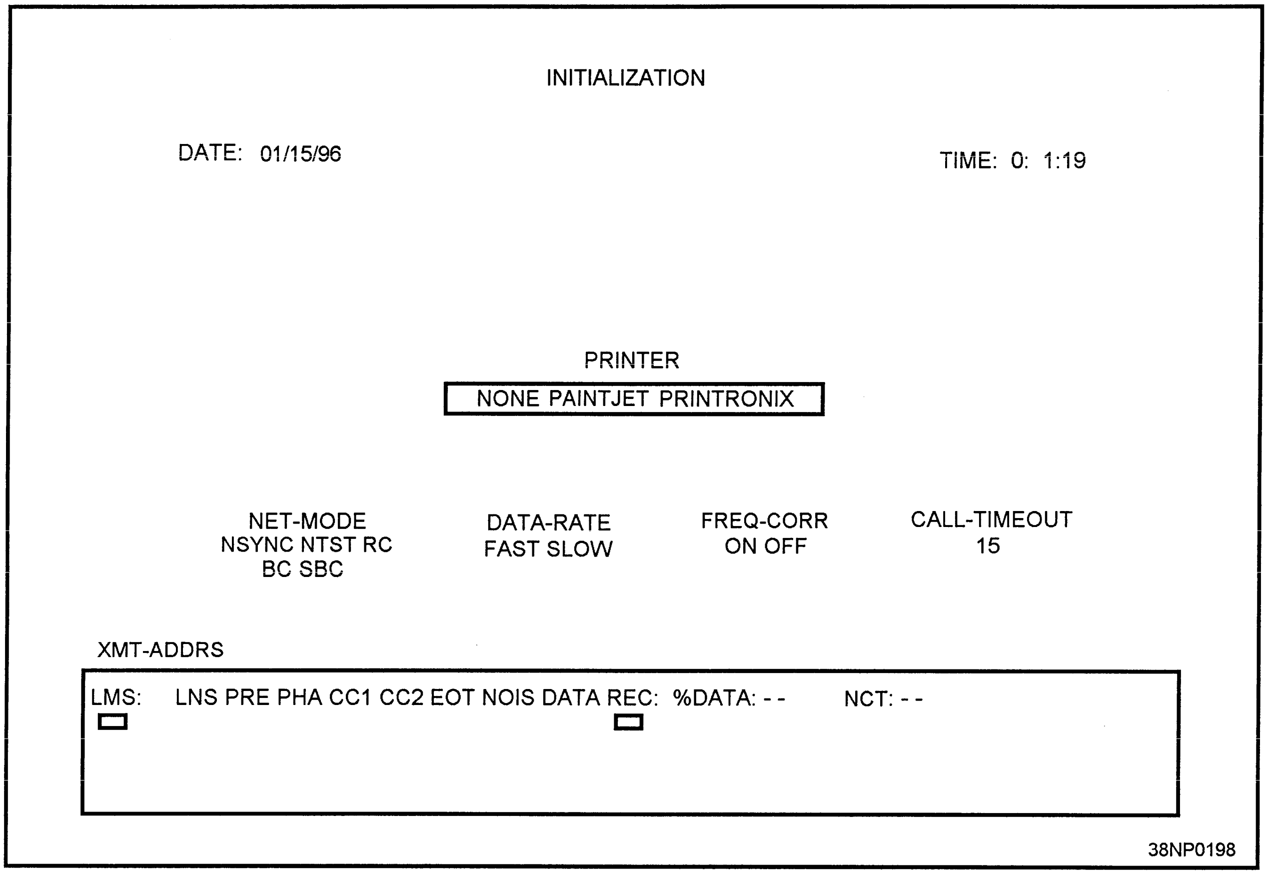

Figure 5-5.—The LMS-11 Initialization display screen.

The top lines of the link monitor display screen contain the header information. The LMS-11 mode is in the top center. The link mode is centered just under the LMS-11 mode. In figure 5-6, this is RC FAST. This means the link is in Roll Call mode, fast data rate. The right side of the header displays the date and time. The left side of the header information allows the operator to enter the NCS address and the sideband to monitor. The LMS-11 uses the address 77 as a default for NCS. However, recall from chapter 2, that 77 is an illegal address and would not be used in an active link. Since NCS never sends an interrogation to itself, the LMS-11 uses this address to designate NCS.

The display sweeps from left to right and from top to bottom. The display is color-coded and uses a stair-step pattern that is easy to understand. The display of a single NCS report and the meaning of the colors and levels is shown in figure 5-7. Figure 5-8 shows how the different messages appear on the LMS-11 link monitor screen. Note that the NCS report ends with the interrogation of the next PU in the polling sequence.

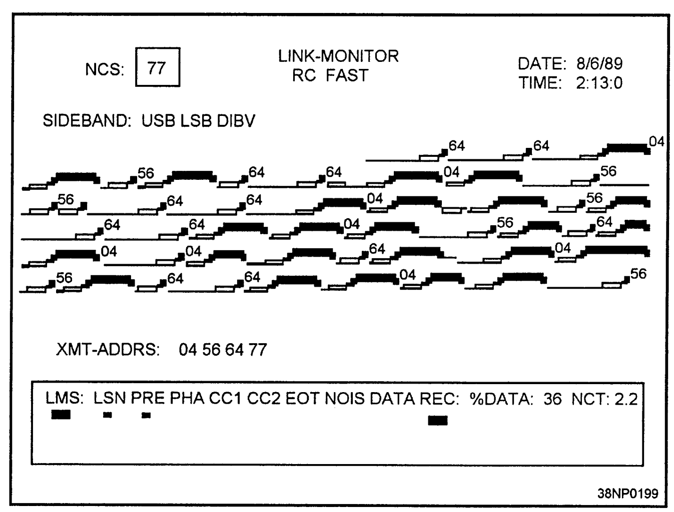

Figure 5-6.—The link monitor display screen.

Study figure 5-6 again and follow the polling sequence of the four units in the net. The last report on the top line is an NCS report and call to PU 04. This is followed by PU 04's response on the left side of line two. Next, PU 56 is called and responds with a picket reply. Upon completion of PU 56's reply, PU 64 is called. After 15 frame times without a response, PU 64 is called again. PU 64 appears to have responded to the second call, but the LMS-11 only recognized the five preamble frames.

By using the link monitor display, the operator or technician can make sure the connectivity has been established and that all the correct PUs are being polled and are responding.

Figure 5-6 also shows several problems that commonly occur during Link-11 operations. Notice that PU 64 sometimes responds to the first call-up, sometimes to the second call-up, and sometimes PU 64 does not respond at all. PU 56 responds all the time except for the call-up at the end of line two and beginning of line three. On line six there is a double response, or echo, from PU 04. If you were to examine this particular sequence using the frame-by-frame analysis, you would find the PU 04 was called again. This indicates the NCS did not receive the report from PU 04 and repeated the call-up during the middle of the response.

Status Display

As shown in figure 5-9, the status display is at the bottom of each of the LMS-11 display screens. The

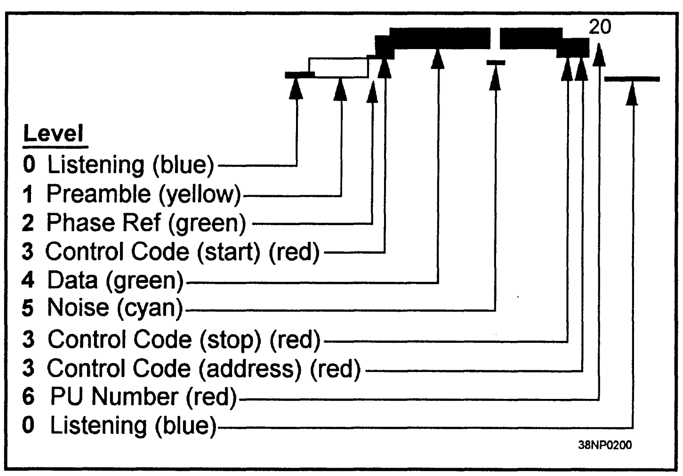

Figure 5-7.—The link monitor display pattern.

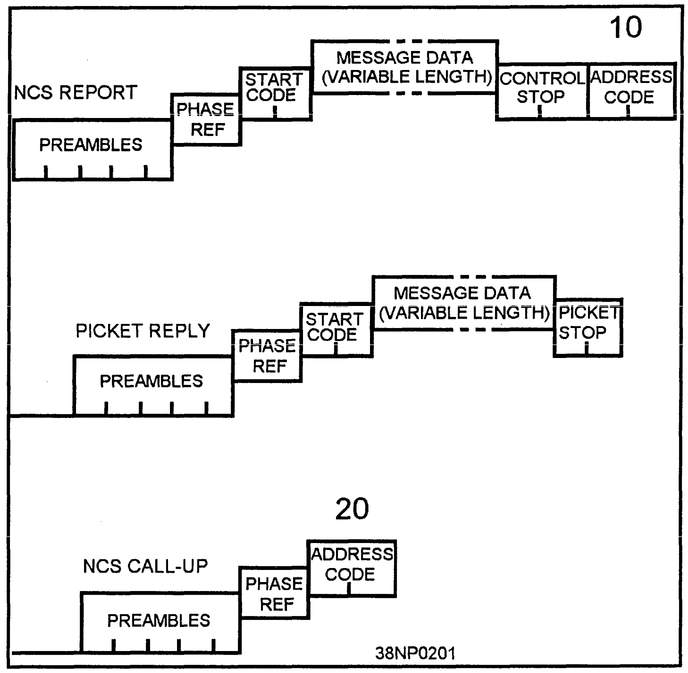

Figure 5-8.—Link-11 messages as displayed by the LMS-11 link monitor mode.

status display consists of the status box and two lines of information just above the status box. The top line, with the heading "XMT-ADDRS:" displays the addresses of all PUs in the order they are being polled. The operator can monitor the polling in real time. The displayed addresses change colors to indicate their status. If the address is yellow, it is currently being interrogated. The yellow address turns green when the start code is received. The yellow address turns red when the PU has been interrogated twice and no response is received.

The line under the "XMT-ADDRS:" is used to display system messages and LMS-11 alerts. Alerts are displayed on the left side of this line. System messages are displayed on the right side of the line.

The status box provides the operator with information about signal processing, link activity, and , raw recording of link data. Just below each of the frame types, a small green box, or light, appears to indicate the type of frame being processed. These signal processing status indicators are not displayed in real time. They are updated approximately every 50 milliseconds. The signal processing indicators are as follows:

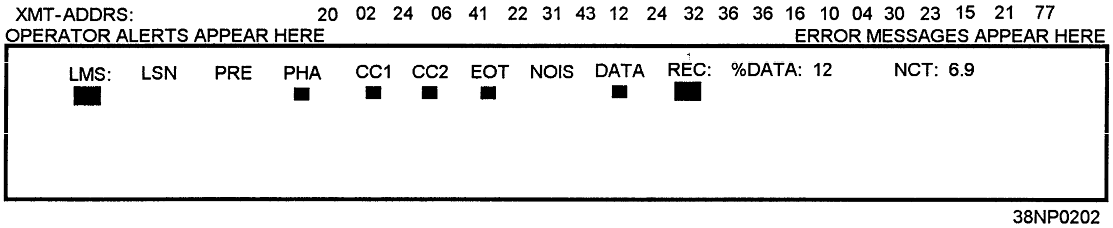

Figure 5-9.—The LMS-11 Status display.

- **LMS** —Should always be green.
- **LSN** —Indicates that the LMS-11 is listening for the link audio.
- **PRE** —Indicates that a preamble has been detected.
- **PHA** —Indicates that a phase reference frame has been detected.
- **CC1** —Indicates the first frame of a control code.
- **CC2** —Indicates the second frame of a control code.
- **EOT** —Indicates that the LMS-11 has detected the end of transmission.
- **NOIS** —Indicates that the received data frame did not pass the data quality test.
- **DATA** —Indicates that the LMS-11 has detected a data frame that has passed the quality test. Note that the control codes and phase reference frames are also data frames.
- **REC** —Shows the status of the raw record function of the LMS-11. The indicator will be green when the recording is turned on and red when the recording is stopped.

The last two fields of the status box indicate the performance of the net. The "%DATA:" field will be followed by a number representing the percentage of net cycle time message data is transmitted with no errors. The "NCT:" displays the net cycle time in seconds. Net cycle time is the time required for one completed polling of the net. It can be measured from control stop to control stop from NCS, or the operator can specify a PU as the reference for net cycle time. The operator can also specify the number of cycles to use to determine net cycle time. The operator makes these entries using the summarize parameter in the NET DISPLAY mode.

Net Display

The Net Display mode is activated when the operator presses the **NET** key on the keyboard. The Net Display mode presents the following two separate types of information: a Net Summary (summarize mode) or a PU History (history mode). In the Net Summary mode, the Net Display presents a summary of quantitative information about the performance of up to 21 PUs. In the PU History mode, the LMS-11 displays data for a selected PU. The most recent 21 transmissions of the specified PU will be displayed while in the PU History mode.

The Net Display mode is only available when the link is in the Roll Call mode. Figure 5-10 shows a screen for the Net Display in the Summarize mode and figure 5-11 shows the screen for a PU History mode.

After the operator enters the Net Display mode, there are four operator entries that can affect the information and how it is displayed. These are NCS, PU, SIDEBAND, and SUMMARIZE. All of the entries are displayed as part of the header of the Net Display screen. The NCS, PU, and SIDEBAND fields are on the left side of the screen, and the SUMMARIZE field is on the right side of the screen just below the date and time fields.

NCS: 77 NET DISPLAY DATE: 9/29/89
PU: 0 RC FAST TIME: 0:12:33
SIDEBAND: USB LSB DIV SUMMARIZE: $\boxed{1}$ CYCLES

PU	SIG PWR	SWR	FRAME CNT	% THRU	CF	BER	REL 605	VAR DATA	PHASE ERR M	PHASE ERR SD	RFE/DS	NCT
77	0	>34	75	100	15	0	6	1	0	3	0	7.0
2	0	>31	13	100	0	0	6	1	1	2	0	7.0
4	0	>34	5?	0	0	0	6	1	1	2	0	7.1
6	0	>31	11	33	0	20	6	1	0	2	0	7.0
10	-51	0	0	0	100	0	0	0	0	0	0	0.0
12	0	14	5?	0	0	8	5	4	8	18	-2	7.0
14	0	22	11	100	0	0	6	2	5	7	-1	7.0
15	0	>23	15	20	0	23	6	1	2	3	0	7.0
16	0	>31	11	33	0	20	6	1	-1	2	0	7.0
20	-51	0	0	0	100	0	0	0	0	0	0	0.0
21	0	23	5?	0	0	0	6	2	0	6	75	7.0
22	0	23	9	0	0	25	6	1	-1	4	15	7.0
23	0	24	6?	100	0	0	6	1	-3	5	-5	7.0
24	0	22	13	100	0	0	6	1	-3	5	-26	7.0
30	-51	0	0	0	100	0	0	0	0	0	0	0.0
31	0	>31	13	100	0	0	6	1	-1	2	0	7.0
32	0	>34	11	100	0	0	6	1	2	3	0	7.0
36	-51	0	0	0	100	0	0	0	0	0	0	0.0
41	0	>30	13	100	0	0	7	2	1	2	0	7.0
43	0	>33	11	100	0	0	7	3	1	2	0	7.1

XMT-ADDRS: 20 02 24 06 41 22 31 43 12 24 32 36 36 16 10 04 30 23 15 21 77

LMS: LSN PRE PHA CC1 CC2 EOT NOIS DATA REC: %DATA: 12 NCT: 7.0

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Figure 5-10.—The LMS-11 Net Display in Summarize Mode.

NCS. —The NCS field allows the operator to designate the PU number of the NCS. When a number is not entered in this field, the default address of 77 is used. It will also be used as the PU number in the polling display of the status area and in the PU field of the Net Display.

PU. —The PU field is used by the operator to designate the PU whose recurring transmission is used to define a cycle. The PU field works with the SUMMARIZE field.

SIDEBAND. —The SIDEBAND field allows the operator to designate which sideband (USB, LSB, or DIV) is used for the information displayed.

SUMMARIZE. —The SUMMARIZE field enables the operator to designate the number of cycles over which the summary is computed. A “cycle” is defined as the recurring transmission from the designated PU. The data is tabulated after the specified number of transmissions are received from the designated PU or after 200 transmissions are received by any station, whichever occurs first. The SUMMARIZE field is also used to enable the PU History mode. The PU History mode is entered when the operator enters a zero in the summary field. When the PU History mode is enabled by the operator, the word **HISTORY** is added to the Net Display title. The PU History mode display updates one line of data immediately after the specified PU has completed its transmission.

The information displayed by the Net Display mode is described in the following paragraphs.

PU. —The PU number. The first number listed is the NCS, which has a default number of 77, or the address entered in the NCS field. The rest of the PUs are listed in numerical order.

NCS: 77 NET DISPLAY HISTORY DATE: 1/15/96
PU: 0 RC FAST TIME: 0:12:33
SIDEBAND: USB LSB DIV SUMMARIZE: 0 CYCLES

PU	SIG PWR	SWR	FRAME CNT	% THRU	CF	BER	REL 605	VAR DATA	PHASE ERR M	SD	RFE/DS	NCT
21	-7	>24	14	100	0	0	6	3	20	6	-4	3.0
21	-6	>23	16	100	0	0	6	3	-4	5	0	3.8
21	-6	>22	16	100	0	0	6	3	1	6	0	3.9
21	-6	>23	22	100	0	0	6	2	-1	4	0	3.3
21	-6	>24	14	100	0	0	6	3	6	5	-1	2.4
21	-6	>22	14	100	0	0	6	3	1	6	0	5.9
21	-6	>22	14	100	0	0	6	3	2	6	0	3.4
21	-6	21	14	100	0	0	6	3	2	6	0	2.8
21	-6	>23	14	100	0	0	6	3	1	5	0	2.8
21	-6	>28	14	100	0	0	6	3	1	4	0	3.8
21	-6	>24	20	100	0	0	6	3	2	5	0	2.2
21	-6	>25	14	100	0	0	6	3	-4	4	0	2.7
21	-6	>23	14	100	0	0	6	3	1	5	0	2.6
21	-6	>22	16	100	0	0	6	3	2	6	0	3.1
21	-6	>22	18	100	0	0	6	3	3	5	0	3.0
21	-6	21	14	100	0	0	6	3	-2	6	0	7.0
21	-6	21	18	100	0	0	6	3	-2	5	0	3.3
21	-6	>23	14	100	0	0	6	3	-2	4	0	2.8
21	-11	>17	14	100	0	0	6	3	6	9	-1	2.5

XMT-ADDRS: 21 16 65 70 61 66 77

LMS: LSN PRE PHA CC1 CC2 EOT NOIS DATA REC: %DATA: 36 NCT: 3.1

38NP0203

Figure 5-11.—The LMS-11 Net Display in PU History Mode.

SIG PWR. —The total signal strength of the 16 tones, measured in dBm. A value of -51 indicates that no signal was received.

SNR. —The signal-to-noise ratio, as measured in dB. The SNR is calculated as the average power in the data tones divided by the average power in the noise tones. The LMS-11 can measure a SNR of near 34 dB. A number preface by the greater than symbol “>” indicates that the average power in the noise tones was below the measurable threshold. In this case, the number represents the data tone signal strength only. An SNR value of 30 or higher is considered excellent. An SNR value of less than 10 is unusable.

FRAME CNT. —A count of all data frames received over the specified number of cycles. Data frames include the phase reference frame and control code frames in each message. A value that is followed by a “?” and color-coded yellow is displayed if the frame count of a picket station average is less than or equal to six frames. The two start code frames, the phase reference frame, the crypto frame, and the two stop code frames would account for the six frames. Therefore, if a picket unit transmits six or less frames, no actual message data is being received and may indicate a problem with the computer or DTS of the unit. A yellow color-coded value followed by the “?” is added for an NCS when the number of frames is equal to or less than eight. The two additional frames account for the next station address at the end of an NCS report.

PERCENTAGE THROUGH. —The %THRU column is a number that indicates the percentage of message data that is received error-free. the percentage is found by comparing the number of error-free message data frames with the total number of message data frames received.

CF. —This is a percentage of control code failures. A PU with strong signals that never misses a call will have a 0 % code failure. A PU that never answers, such as a dummy PU, will have a 100 % code failure.

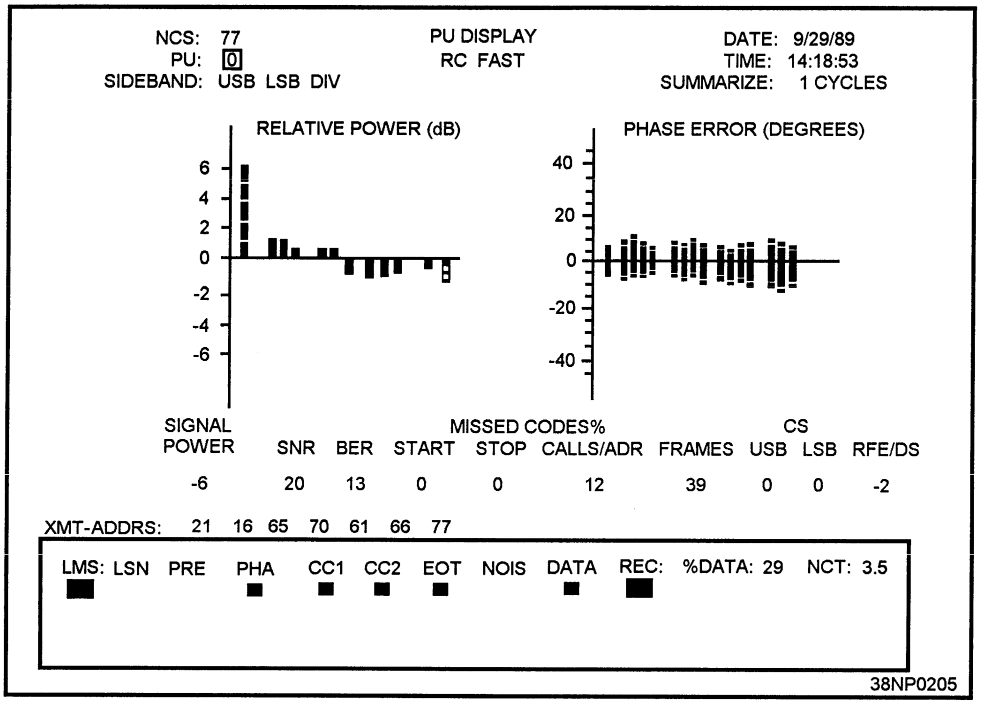

Figure 5-12.—The LMS-11 PU Display mode.

Values between 1 and 100 could be due to noise or weak equipment or an equipment malfunction.

BER. —This is the bit error rate measured as the number of bit errors per 1,000. Bit errors increase as the signal-to-noise ratio decreases. A bit error rate that exceeds a theoretical value for a given SNR is indicated by displaying both the BER and SNR in yellow.

REL 605. —This column indicates the relative power of the 605-Hz tone with respect to the average power of the 15 data tones, measured in dB. It should be +6 dB.

VAR DATA. —This is the variation of power in the data tones in dB. The relative power of each of the data tones, with respect to the average power of the data tones, is determined. The variation is the difference between the maximum and the minimum. Under ideal conditions, the variation is zero. The TADIL A specification for maximum variation is 1.5 dB.

PHASE ERR M. —This is the mean, or average, phase error of the data tones. The intelligence is stored in the data tones by use of the phase differences that are odd multiples of 45 degrees. If the phase difference of a data frame is 50 degrees when the expected difference is 45 degrees, the error would be 5 degrees. The phase errors for each tone are added up, and after the specified number of cycles, the sum for each tone is divided by the number of frames to obtain the mean phase error for each tone. The mean phase error for all 15 tones is then summed and divided by 15 to obtain the value displayed.

PHASE ERROR SD. —This is the standard deviation of the phase error in all 15 tones.

RFE/DS. —This is the radio frequency error, or Doppler shift, measured in Hertz. If the Doppler correction was enabled during the LMS-11 initialization, the value is color-coded green. If the Doppler correction is turned off, this value is color-coded cyan.

NCT. —This is the net cycle time, as measured from phase reference frame to-phase reference frame, of the reporting unit. Note that this measure of net cycle time is different from that used in other NCT calculations.

PU Display

The PU display shows detailed information about the signal received from the specified PU. The PU display can operate in broadcast, short broadcast, and Roll Call modes. In Broadcast and Short Broadcast, the display is updated after every transmission. In Roll Call mode, the display is updated after the specified number of net cycles or 200 transmissions, whichever occurs first. When the net cycles are set to zero, the display updates immediately after the designated PU has transmitted. The PU display is shown in figure 5-12.

The PU display is activated when the operator presses the PU function key on the keyboard. The information in the PU display is presented in two bar graphs with additional amplifying information just under the bar graphs. In the PU display header, the operator enters the address of NCS (or 77), the address of the unit to be evaluated, the sideband to be evaluated (USB, LSB, or DIV), and the number of cycles to summarize for the display. The following paragraphs describe the information presented in the PU display.

RELATIVE POWER (dB). —This bar graph displays the relative power in each of the Link-11 tones. The relative power is calculated with respect to the average of the data tones. The expected values should be +6 dB for the 605-Hz tone (tone 5) and 0 dB for the data tones. The TADIL A specifications allow for a difference of 1.5 dB between the maximum and minimum power levels of the data tones. A noisy signal may cause the power levels of the data tones to deviate considerably from the standard. The bar graph for relative power is also color coded. When the relative power of a data tone is ±1 dB, the bar is green. If the power level is in the range of +1 to +2 dB or –1 to –2 dB, the bar will be yellow. The bar is red if the power level is greater than +2 dB or less than -2 dB. The length of the bars plotted on the graph is rounded off to the nearest 1/2 dB.

PHASE ERROR (DEGREES). —The phase error (degrees) bar graph shows the mean and the standard deviation of the Link-11 tones. The standard deviation of a tone is plotted by a color bar on the graph. The size of the color bars is plotted to the nearest whole degree of deviation. The mean deviation of the tone is indicated by a small white line, usually in the center of the standard deviation color bar. The mean phase error should fall between +45 degrees and -45 degrees. If the data is bad, the mean phase error is set to -45 degrees and the standard deviation is set to 90 degrees. This causes the bar to be drawn across both quadrants of the graph.

The standard deviation is represented by a color-coded bar for each tone. A green bar is displayed if the standard deviation is within 10 degrees. Deviations between 10 degrees and 20 degrees are represented by a yellow bar, and deviations greater than 20 degrees are red. The standard deviation must be a positive value that is less than 45 degrees. If the standard deviation is out of range for a given tone, the data is bad. This condition is indicated by the LMS-11 by setting the mean deviation to 45 degrees and the standard deviation to 90 degrees. As with the mean deviation phase error, this causes the bar to be painted in both quadrants of the graph.

Some causes of phase errors are noise, simultaneous transmissions, poor framing, and errors in Doppler correction due to noise on the preamble. For example, a picket unit transmitting Net Sync during Roll Call will cause an error condition. The expected value of the mean deviation is 0 degrees with a standard deviation of ±5 degrees. If only one tone has a mean value that is greatly different from the other tones, it may be an indication of a frequency error on that tone.

SIGNAL POWER. —The signal power is part of the amplifying information under the two bar graphs. The signal power is the total signal strength in the 16 tones. It is measured in dBm. If no signal is received, the default value of -51 dBm is listed.

SNR. —This is the signal-to-noise ratio. It is measured in dB and calculated as the ratio of the average power in the data tones to the average power in the noise tones. If the SNR value is preceded by the symbol ">," it indicates that the average power in the noise tones is below the measurable threshold and the actual SNR is greater than the value indicated. The maximum value that the LMS-11 can measure is about 34 dB. An SNR that is greater than 30 dB is excellent. If the SNR is less than 10 dB, the data is unusable.

BER. —This is the bit error rate per thousand. The incidence of bit errors increases as the signal-to-noise ratio decreases.

MISSED CODES PERCENTAGE. —This is a percentage of each type of code that is missed. The number of codes (start, stop, and address call-ups) missed and received is tabulated and the percentage of each type missed is calculated.

FRAMES. —This is the total number of data frames received, including the phase reference and control code frames.

CS. —This field displays the carrier suppression value of the upper and lower sidebands as a ratio of the power in the 605-Hz to the power of the carrier frequency. The value display is measured in dB.

RFE/DS. —The radio frequency error or Doppler shift of the received signal in Hertz. The display is color-coded cyan if frequency correction was disabled during LMS-11 initialization.

Spectrum Display

The spectrum display graphically shows the power levels of all the Link-11 tones and the noise tones that are the odd harmonics of 55 Hertz. The spectrum display screen is shown in figure 5-13. The x-axis of the bar graph is numbered from 1 to 30 to represent 30 tones. Tone 05 is the 605-Hz Doppler tone. Tones 8 through 21 and tone 26 are the data tones. The remaining tones are not used by the Link-11 system but are sampled and displayed to give the operator an indication of the noise level.

The y-axis of the bar graph displays the relative power of each tone in dB. The highest value of the scale is 0 dB and decreases to -40 dB. The tone with the greatest amount of power is set to 0 dB on the scale. This should be the 605-Hz tone. The remaining tones are measured relative to the tone with the greatest power. A single blue line is drawn horizontally across the screen at the -6 dB level. Ideally, all data tones should extend up to this line.

The 605-Hz tone and the data tones are displayed by solid green vertical lines. If the power of a data tone is greater than -6 dB with respect to the 605-Hz tone, the area above the -6 dB line is indicated by an open yellow bar on top of the green bar. If the power level of a data tone is below the -6 dB threshold, an open yellow bar is used to fill in the remaining distance. This allows the operator to view the effects of the noise. The power of the noise tones is also indicated by open yellow bars.

To enter the spectrum display, depress the SPECT key on the keyboard. Several options are available to the operator by entering data into the header fields of the spectrum display. The operator may designate the address of the NCS. The default address is 77. The operator can also select a particular sideband (USB, LSB, or DIV) for display. By using the RESTRICT field, the operator can restrict the display to only data frames or only preamble frames, or choose no restrictions. The PU field allows the operator to designate a particular PU for display. If 00 is entered into the PU field, then the data display is continuously updated with samples from the entire net.

Carrier Suppression Display

The carrier suppression display measures how successfully the carrier frequency is suppressed. The carrier suppression measurements can only be made during Net Sync. To measure the carrier suppression, the radio must be off-tuned by -500 Hz for the upper sideband and +500 Hz for the lower sideband. This off-tuning allows the program to measure and compare the relative power of the carrier frequency and the 605-Hz tone of the preamble.

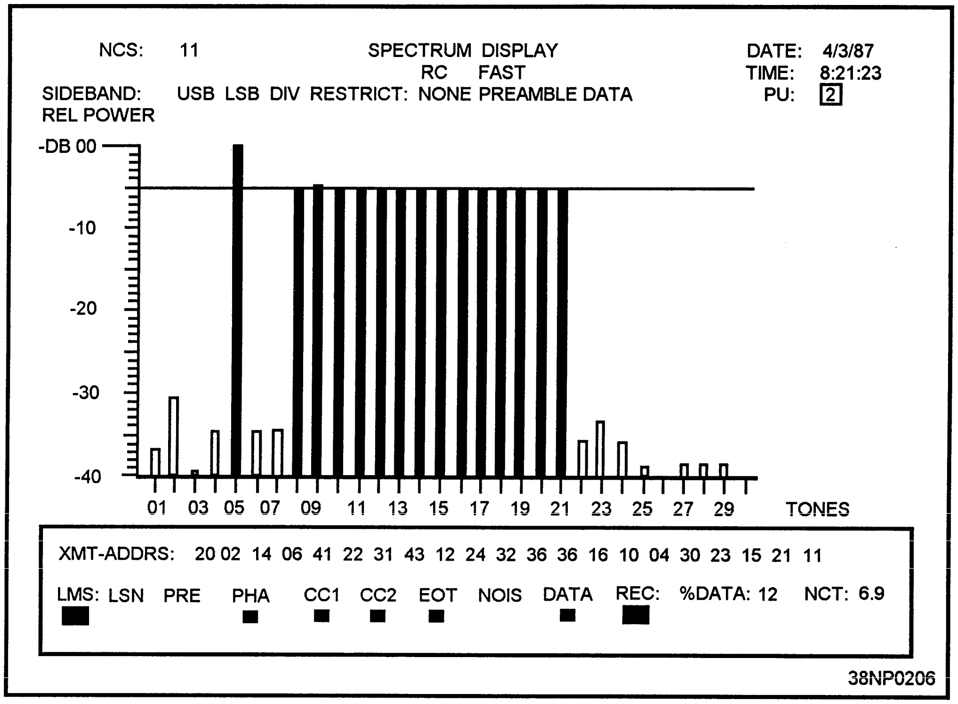

Figure 5-13.—The Spectrum Display screen of the LMS-11.

RECOGNIZING LINK-11 NET PROBLEMS

The LMS-11 is very useful in evaluating Link-11 net quality. As you have seen, the various on-line modes can help you determine various problems. These include a station that is consistently missing call-ups, poor signal-to-noise ratio, and low power from a unit. Some common Link-11 problems and the LMS-11 display are covered in the next few paragraphs.

Figure 5-14 shows an example of how a PU not responding to call-ups would appear on the LMS-11 operating in the Link Monitor mode. When a PU does not respond to a call-up, the reason may be that the incorrect PU number was entered at the NCS or at the DTS of the unit. It can also be caused by a poor receiver at the PU, causing the PU to not receive its call-up. A third problem could be a weak transmitter at the PU, causing the NCS to not receive the response and therefore, repelling the PU.

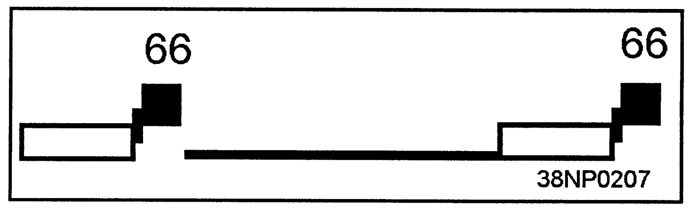

Figure 5-14.—A PU not responding to NCS call-up.

Figure 5-15 shows the display that appears when a PU is responding to NCS call-ups, but the report contains no data. Causes of this problem could be the KG-40 has an alarm, the CDS program is down, or the problem is in the CDS computer to DTS patching.

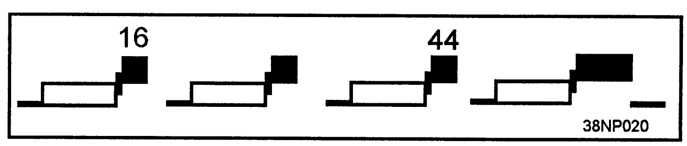

Figure 5-15.—A PU responding with no data.

When NCS fails to receive a stop code from a PU, it causes a stoppage of the net, as shown in figure 5-16. If this condition occurs repeatedly and can be traced to a single PU, the NCS should delete the PU until the stop code problem in the DTS is corrected.

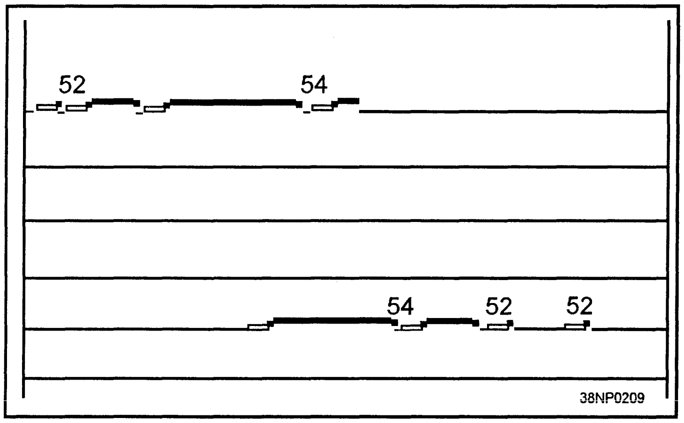

Figure 5-16.—A net stoppage caused by NCS not receiving a stop code.

Figure 5-17 shows several PUs not responding to call-ups. Some of the causes for this condition could be the following: NCS having an incorrect PU address entered in the DTS, low transmitter power out from NCS, an excessively noisy frequency, or weak PU receivers.

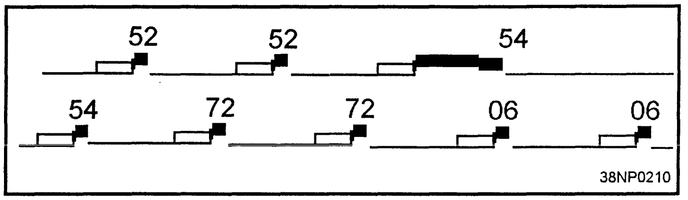

Figure 5-17.—Several PUs not responding to NCS call-ups.

The LMS-11 also has several off-line modes that allow you to save data onto a disk and analyze the data in detail. The off-line modes include a frame-by-frame display to analyze each frame of a transmission. This allows you to analyze the data of a particular PU and shows the status of each bit position. Remember that when you are doing a frame-by-frame analysis, the data has not been decrypted.

More information on all modes of the LMS-11 can be found the *System Operation and Maintenance Instructions, Organization Level, Link Monitor System AN/TSQ-162(V)1,* EE-190-AB-OMI-010/TSQ-162(V)1.